IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Carpenter *et al.*		
Serial No.:	09/769,670	Group Art Unit:	2831
Filed:	01/25/2001	Examiner:	Patel, D.
For:	Grounding Systems for Floating Roofs in Flammable Storage Tanks	Attorney Docket:	RM26ii

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF NON-OBVIOUSNESS PURSUANT TO 37 CFR § 1.312

Dear Sir:

I, Roy B. Carpenter, Jr., am the Chief Executive Officer for Lightning Eliminators & Consultants, Inc. ("LEC"). LEC is the owner of the assigned interests in the instant application. I am also a co-inventor of the claimed invention.

LEC was formed for the specific purpose of providing engineering expertise in the field of lightning protection design, grounding systems engineering and surge protection design. LEC has been providing consultation services and systems worldwide since 1971.

LEC manufactures and sells the *Retractable Grounding Assembly™* ("RGA"). The RGA was designed to overcome and eliminate known problems in the oil storage industry. The industry has suffered frequent fires and has been looking for a solution for the problem for the past 100 years. The American Petroleum Institute (API) Recommended Practices 2003 Section 6.5.2 (attached as Exhibit A) lists the connection between the tank wall and roof as a significant cause of fires and a major maintenance problem. API also lists mechanical shunts as the only known current solution. However, API recognizes that shunts require constant maintenance.

As illustrated in my article <u>Making a Connection Between the Tank Wall and the Floating Roof</u> (attached as Exhibit B), there are known problems in the industry involving shunts. Shunts have been installed in large crude storage tanks to form a connection to the earth in order to eliminate bound charges and arcing. However, history has proven that these

shunts require constant maintenance for several reasons. These reasons include, but are not limited to:

1. Since the roofs of the storage tanks float, the roof can easily drift off center and disconnect from the opposite side.
2. Wax and other heavy crude components tend to deposit between the tank wall and the shunt fingers forming an insulator between them.
3. The gap is so small that an arc can easily jump that space and ignite a fire when a charge is on the product. This is called a "rim fire."
4. Submerged shunts will suppress the arc and reduce the risk of rim fires; however they will not influence that risk related to nearby lightning discharges or that related to direct strikes to the tanks. A secondary arc can be formed in any air space between the roof and the tank wall, inside or outside the roof. This is the result of circuit impedances that allow the charge to be held near the center of the product in the tank.
5. Within the past two years, many of these tanks have been painted with a polymer on the inside wall, thus insulating the wall from the shunts, rendering them useless and mandating RGA's. It is noted that most oil companies are now implementing this change in their tank farms to reduce the rusting trends.

During electrical storms, the electrostatic field will induce a charge on both the tank and the contained product. Normally, dissipation array systems will discharge both the tank and the product for most situations. However, if the tank has a large diameter and the storm cell contains an unusually large charge, the product near the center will not be discharged fast enough. Then, if the shunts are not in perfect contact with the tank wall, a "bound charge" will build up and create an arc between them when the storm cell is discharged by a nearby lightning strike. Please refer to the API Recommended Practices RP2003 pages 23-24 (Section titled: Protection of Specific Equipment Against Lightning) for details on the Bound Charge/Secondary arc which is attached as Exhibit C.

Companies have tried for years to overcome the known problems associated with these shunts. Some companies have tried to use long wires that extend from the top of the tank wall down to the center of the floating roof. Worse yet, they extend the wire to one edge of that roof. However, the impedance of that wire is far too high to react within the time available to discharge a bound charge (about twenty microseconds). The average inductive impedance of these connections can exceed 500 ohms at lightning frequencies. In

the past, it has proven very difficult to make a positive connection between the floating roof and the tank wall all the time and with a path impedance low enough to eliminate this risk and risk charge buildup during product transfer or any other phenomena that can create charge buildup on the product. For example, high flow rates during the tank filling process can create a significant charge on the product. It is noted that a recent earthquake in Japan caused the product to take on a charge resulting in a fire because of the rocking motion of the tank. A detailed discussion of the potential problems encountered when trying to make this positive connection can be found in my attached article, <u>Making a Connection Between the Tank Wall and the Floating Roof</u> which is attached as Exhibit B.

The API has even taken an interest in solving the shunt problem. They commissioned a study to verify if lightning protection requirements for above ground hydrocarbon storage tanks were adequate; to define practical testing procedures for checking the adequacy of arrangements on tanks in the field; and to develop and publish practical guidance on how to maintain these arrangements to ensure continuing adequate protection. The project was split into two phases, the aim of Phase 1 being to establish the necessary criteria/parameters for the majority of the experimental testing to be carried out in Phase 2. Phase 1 was completed in July 2004. Based on the key finding that the shunts provide inadequate contact to prevent arcing and sparking, Phase 2 will not be carried out as originally specified. The API is currently seeking feedback from the industry and key stakeholders on the scope of the work that should be carried out in Phase 2. Please see attached Exhibit D.

LEC developed the RGA device to provide a direct connection to the tank roof from the tank wall, using a wide and thick-braided wire, wound on a reel and held in tension by spring loading. The path of impedance is held to a practical minimum by the combination of the shortest path, the wide braid and the constant tension. The wide braid is to reduce the "skin effect" at lightning frequencies, and facilitate a tight wind on the reel. The design objective was to achieve the lowest possible impedance between the roof and the wall of the tank. Even the bearings are oilite bronze. The RGA is nearly 100% effective and is virtually maintenance free. Further it is independent of the condition of the tank wall and that of any shunts; in fact it also works if no shunts are present. The RGA product directly corresponds to the invention claimed in the referenced patent application.

As indicated above, there is objective evidence that an art recognized problem has existed in the oil storage industry for a long period of time without solution. Those of ordinary skill in the art have recognized that shunts provide inadequate contact to prevent

arcing and sparking. This long-felt need has not been satisfied by anyone else in the industry, despite constant attempts to do so. The above-referenced invention satisfies this long-felt need.

LEC's *Retractable Ground Assemblies*™ are very successful commercially. I have been in the "lightning eliminating business" for more than 34 years and believe that the success of our RGA's can be attributed directly to the claimed features which are described in the above-referenced patent application. Since the first release of our RGA's, LEC's RGA sales have increased incrementally each year and we have sold approximately $800,000 worth of RGA's in the past five years. Our commercial success is not a result of promotion, advertising or other factors that are extraneous to the merits of the claimed features. I believe this is supported by not only our sales performance, but by the fact that LEC does not extemporaneously promote or advertise the RGA's nor do the RGA's contain a licensed brand. We have sold approximately 400 units to sophisticated buyers including but not limited to Shell Oil, Mobil Oil Co. and Bahamas Oil Refining Co. Intl.

As a co-inventor, I am not aware of anyone combining the prior art elements cited by the Examiner to obtain LEC's claimed invention. As the Chief Executive Officer of my company, charged with determining marketable and profitable items, I can attest that before LEC introduced this *Retractable Grounding Assembly*™, LEC was not aware of anyone making a device of this type to combat the known problems involving shunts in the oil storage industry.

Respectfully submitted by,

Roy B Carpenter Jr

Name

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Title

Feb. 2 2005

Date

sure–vacuum vent valves, without flame arresters, have been proved to satisfactorily stop a flame from propagating into the tank. To reduce the ignition hazard, some companies forbid the opening of gauge hatches during lightning storms.

6.5.2 FLOATING-ROOF TANKS

6.5.2.1 Open Floating-Roof Tanks

Fires have occurred when lightning has struck the rims of open floating-roof tanks when the roofs were quite high and the contents were volatile. Most of these fires occurred above the seal and were extinguished with hand foam lines or portable dry-chemical extinguishers. Similar above-the-seal fires have occurred when lightning has struck the rims of floating-roof tanks and ignited flammable vapors above the floating roof. These fires have occurred when the roofs were low. Seal fires have occasionally resulted at leakage points in the seal.

Fires have occurred in the seal space of open floating-roof tanks as a result of lightning-caused discharges. Ignition can be from a direct strike or from the sudden discharge of an induced (bound) charge on the floating roof. The induced charge is released when a charged cloud discharges to the ground somewhere in the vicinity of the tank.

Metallic straps (shunts) placed at intervals of not more than 3 meters (10 feet) on the circumference of the roof, between the floating roof and the metallic shoe that slides on the inside of the shell, will permit the charge to drain off without igniting vapor under the fabric seal. Where weather shields are present above the seal, or where wax scrapers or secondary seals are provided, the space between the two seals may contain a flammable vapor–air mixture; shunts should therefore be placed so that they directly contact the tank shell above the secondary seal. The shunt spacing interval should be the same as that recommended above.

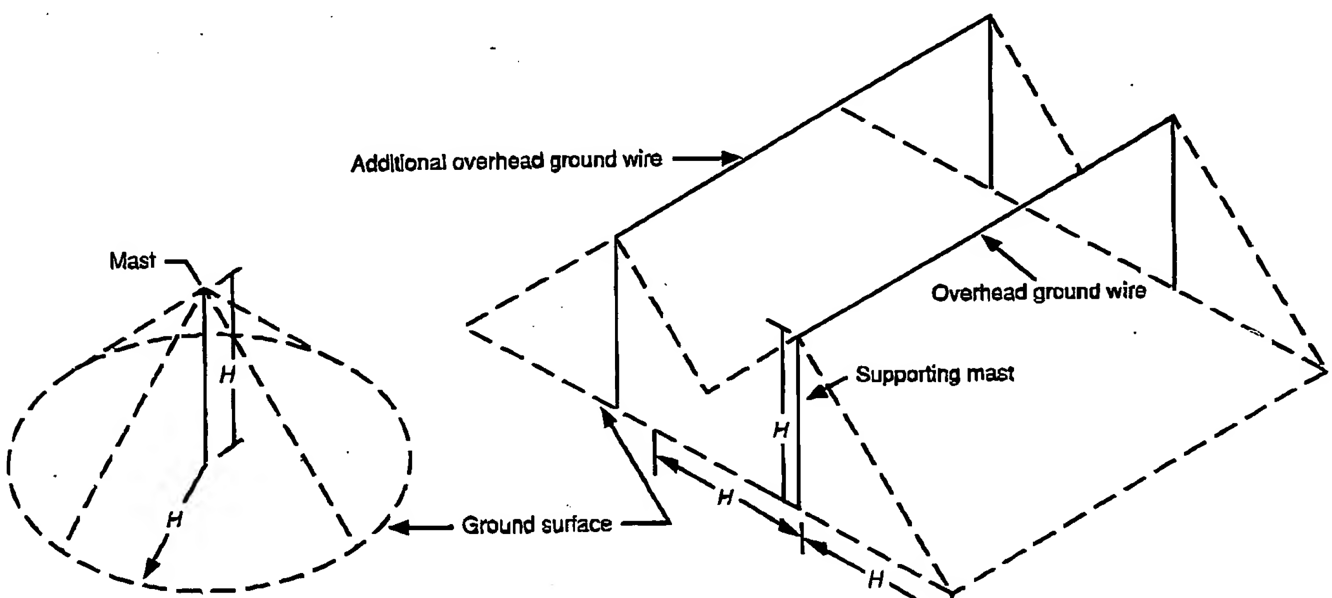
The most effective defense against ignition by a direct strike is a tight seal.

6.5.2.2 Internal Floating-Roof Tanks

Internal floating-roof tanks with conductive roofs are inherently protected against lightning by the Farraday-cage effect. The floating roof or cover still requires bonding to the shell for protection against electrostatic charges due to product flow (see 4.7). If nonconductive roofing materials are used to enclose the tank, the recommendations for lightning protection given in 6.5.1 apply. In addition, an internal floating roof should be treated in the same way as an open floating roof for seal protection (see 6.5.2.1).

6.5.3 PRESSURE STORAGE

Metallic tanks, vessels, and process equipment that contain flammable liquids or gas under pressure do not normally require lightning protection. Equipment of this type is usually well grounded and is thick enough not to be punctured by a direct strike.



SINGLE MAST—
ZONE OF PROTECTION DEFINED BY
DASHED LINES

OVERHEAD GROUND WIRES—
ZONE OF PROTECTION DEFINED BY
GROUND WIRES AND DASHED LINES

Figure 10—Zone of Protection for Mast Height, *H*, Not Exceeding 15 Meters (50 Feet)

Making A Connection Between The Tank Wall And The Floating Roof

Revised June 2004

Background

The roofs of many large crude storage tanks are open in the sense that there is not a permanently attached roof. It floats on top of the product. To prevent vapors from escaping from around the edge of the roof, it is common to provide some sort of seal. These seals are made of a non-conductive material, usually neoprene. This material isolates the roof from the tank wall electrically, and from any connection to earth. To overcome this problem, the industry usually installs a device called a "shunt." These shunts are attached to the roof in such a manner that they are to be in constant contact with the tank wall regardless of the position of the floating roof. To make contact, these shunts are usually made with metal fingers, which are designed to make contact with the tank wall directly. The contact resistance depends on the characteristic of the material used. The contact pressure and the state of the tank wall. History has proven that these shunts require constant maintenance for several reasons. These include:

1. Since the roof does float, it can easily drift slightly off center and disconnect from the opposite side.

2. Wax and other heavy crude components tend to deposit between the tank wall and the shunt fingers forming an insulator between them.

3. The gap is so small that an arc can easily jump that space, and ignite a fire when a charge is on the product. This is called a "rim fire".

4. Submerged shunts will suppress the arc and reduce the risk of rim fires; however they will not influence that risk related to nearby lightning discharges or that related to direct strikes to the tanks. The secondary arc can be formed in any air space between the roof and the tank wall, inside or outside the roof. This is the result of circuit impedances that allow the charge to be held near the center of the tank.

During an electrical storm, the electrostatic field will induce a charge on both the tank and the contained product. If that tank is protected with a Dissipation Array® System (DAS®), that DAS will discharge both the tank and the product for most situations. However, if the tank has a large diameter, the storm cell contains an unusually large charge, the product near the center will not be completely discharged. Then, if the shunts are not in perfect contact with the tank wall, a "Bound Charge" will build up and create an arc between them when that storm cell is discharged by a nearby strike. Refer to the American Petroleum Institute (API) Recommended Practices RP2003 for details on the Bound Charge/Secondary Arc.

The Prevention Requirement

Some companies have tried to use long wires that extend from the top of the tank wall down to the center of the floating roof. Worse yet, they extend the wire to one edge of that roof. However, the impedance of that wire was far too high to react within the time available to discharge a bound charge (about one microsecond). The average inductive impedance of these connections can exceed 500 ohms at lightning frequencies.

Making a positive connection between the floating roof and the tank wall, all the time and with a path impedance low enough to eliminate this risk and the risk other phenomena that can create any other body of bound charge on the product. For example, high flow rates during the tank filling process can create a significant charge on the product.

The subsequent photographs illustrate some of the potential problems encountered in trying to make that connection.

Figures 1 and 2 illustrate a typical approach to making a connection, using two to four-inch wide stainless steel shunts. At close inspection, some do not touch the wall; others appear to make a connection. But when measurements of the contact resistance are made, it yields a high resistance or no connection at all. Rust was found to function as an insulator.

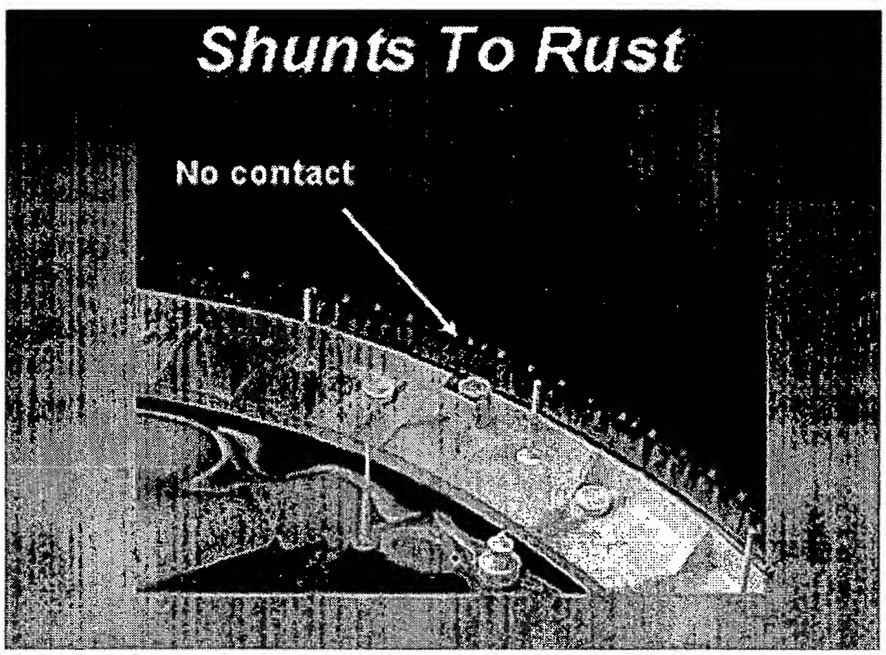


Figure 1.

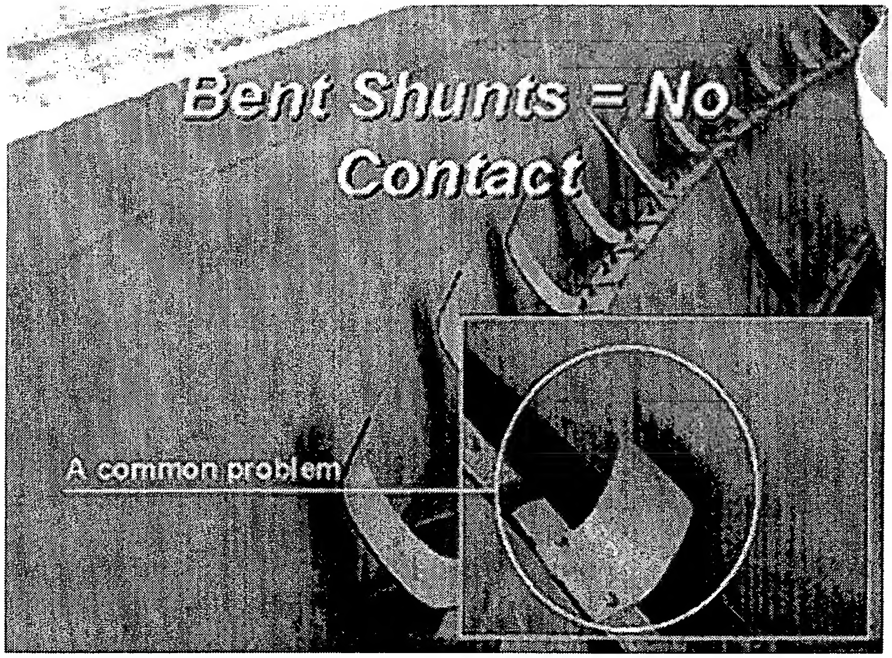


Figure 2.

Figure 3 illustrates a different form of shunt. However, measurements indicated no connection or high resistance. Again, as the result of a combination of rust, low pressure on the wall and/or heavy hydrocarbon accumulation on the tank wall.

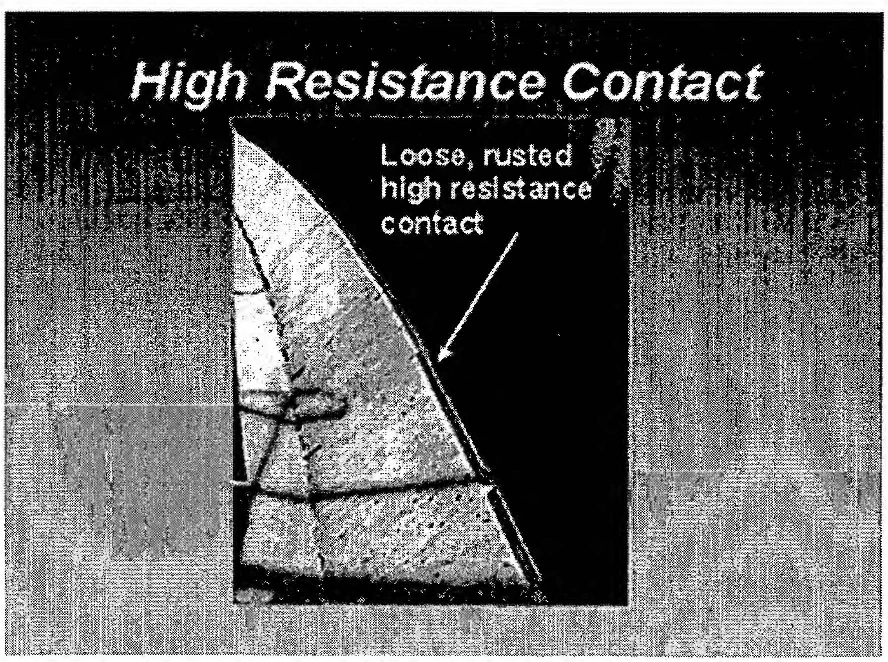


Figure 3.

Figures 4 and 5 illustrate a new trend in the industry. The tanks are being painted inside and out with a non-conductive polymer. Further, to prevent scratching that paint, they often disconnect the shunts as illustrated by Figure 5 and then paint the shunts.

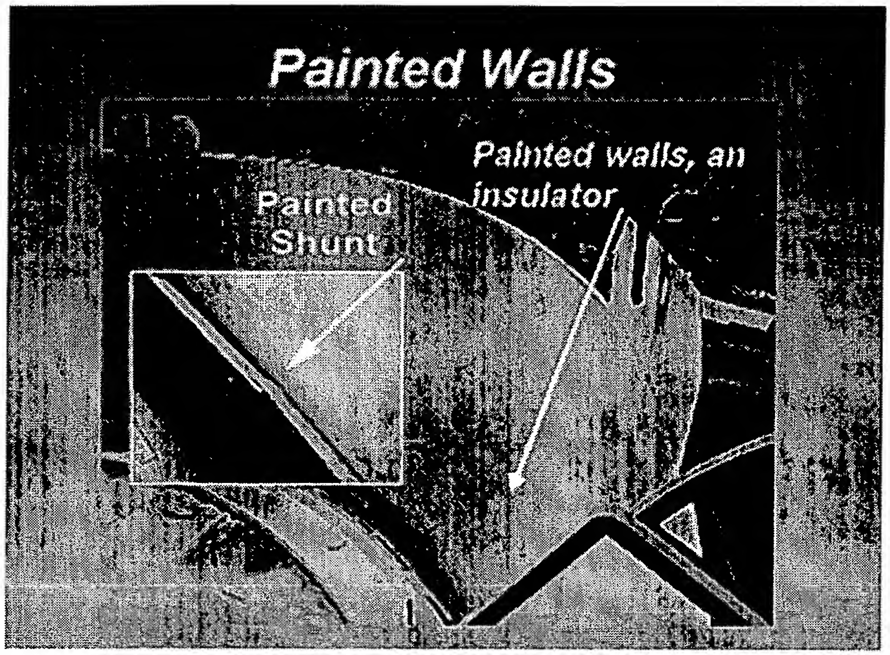


Figure 4.

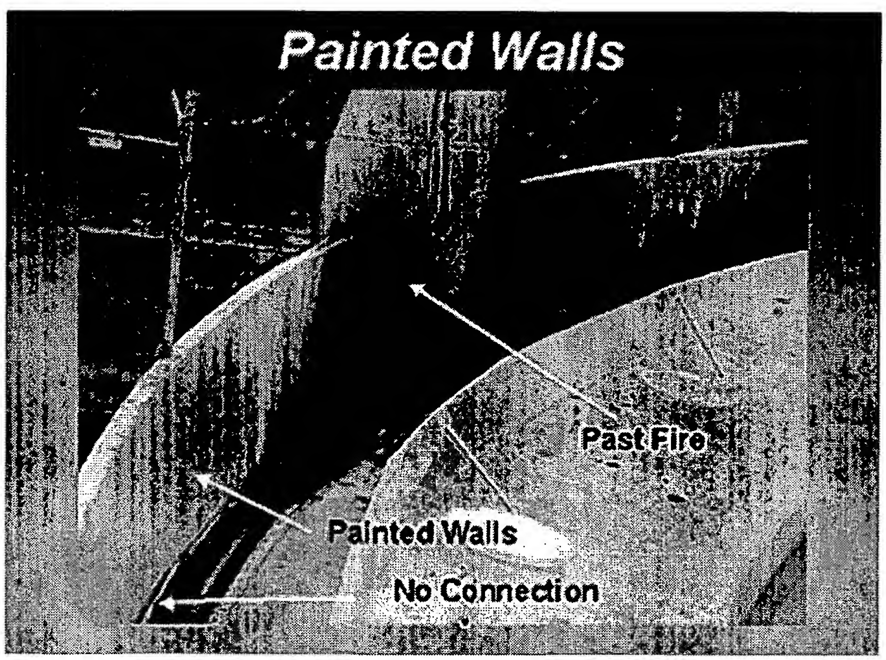


Figure 5.

Figure 5 illustrates the results where arcing initiated a rim fire. The connections "looked" satisfactory, but in fact were not; the paint insulated the roof from the wall.

Figures 6, 7 and 8 illustrate a variation of a conventional concept where the access ramp connecting the top of the tank wall to the roof was used to make the connection.

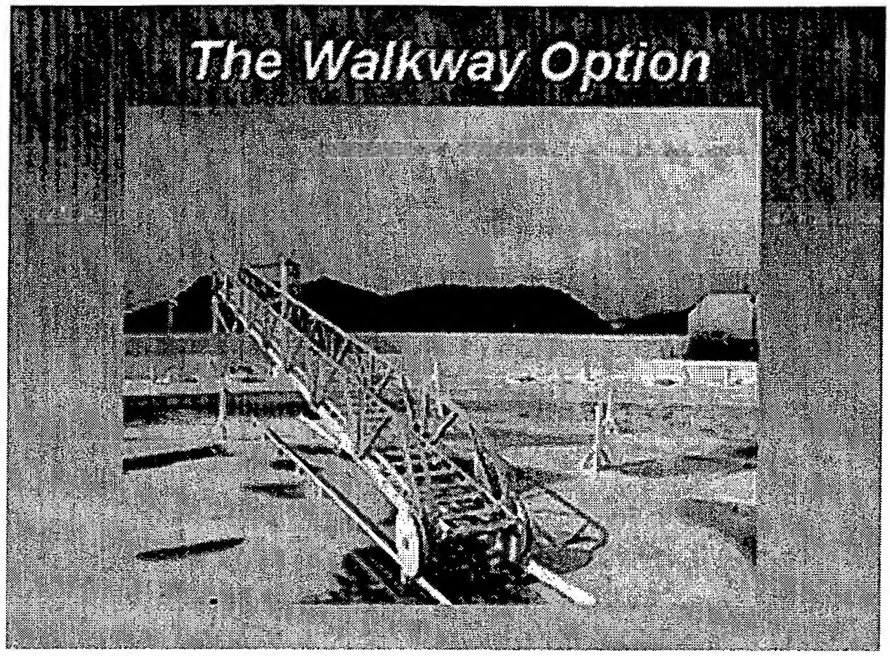


Figure 6.

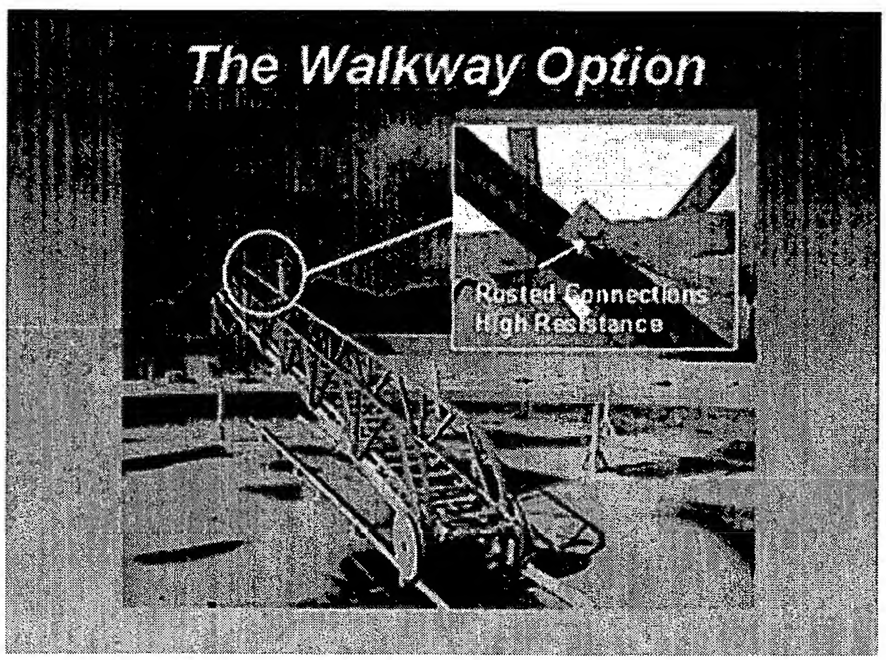


Figure 7.

Figure 7 illustrates a typical bolted connection to a painted structural member. Rust and paint insulate the joint.

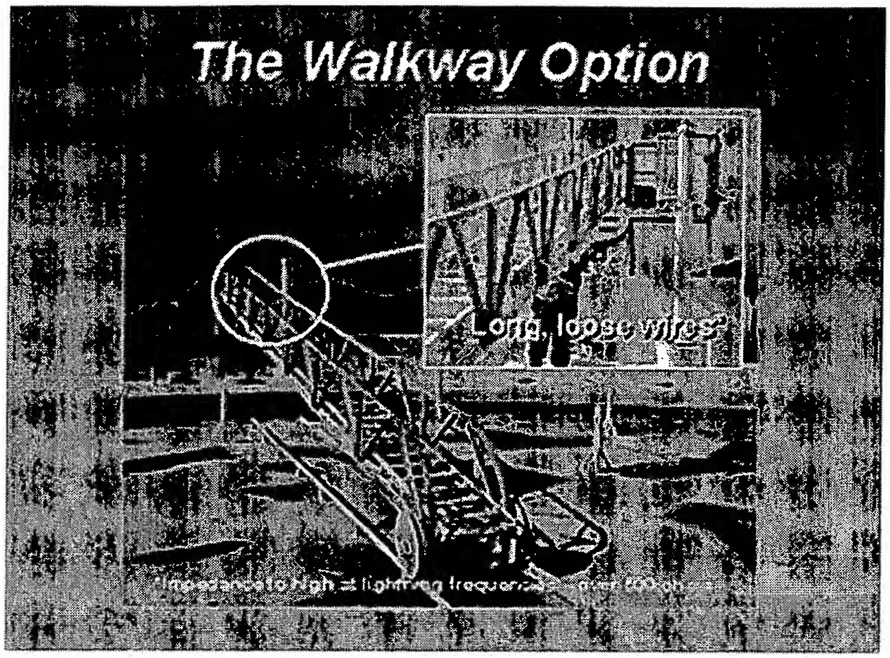


Figure 8.

Figure 8 illustrates a typical wire connection from the tank top to the ramp. It is long and loose. The reactance of this "connection" is far too high and found to be 500 ohms to lightning current flow.

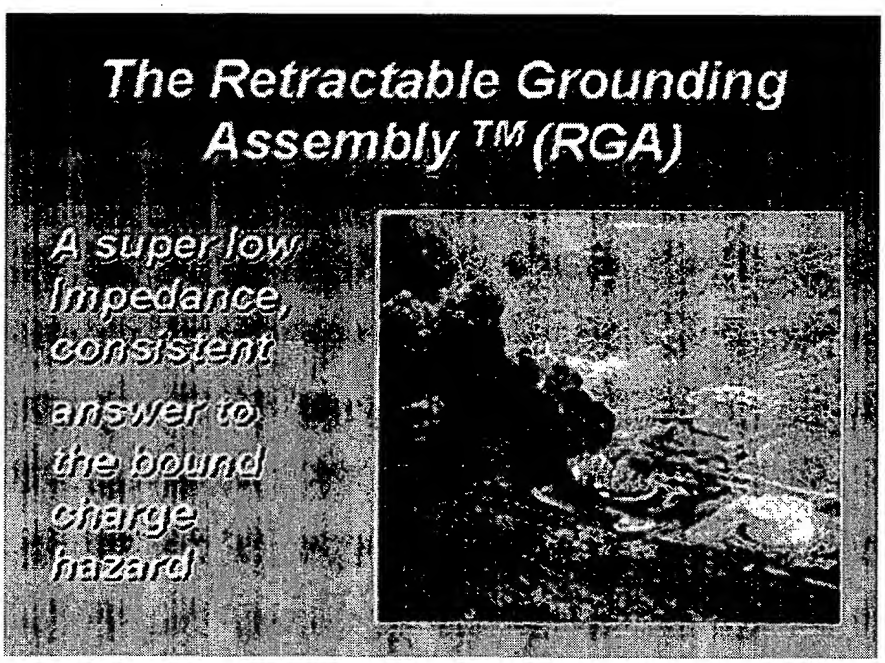


Figure 9.

Figure 9 illustrates the result of a lightning-initiated fire where bound charge was allowed to remain in the tank when lightning terminated nearby.

LEC has developed an assembly that will provide a very low-impedance connection to the floating roof grounding and bonding provided in one modest assembly. The LEC Retractable Grounding Assembly (RGA) is 100% effective and is virtually maintenance free. Further, it is independent of the condition of the tank wall and that of any shunts; it also works if no shunts are present. See Figure 10.

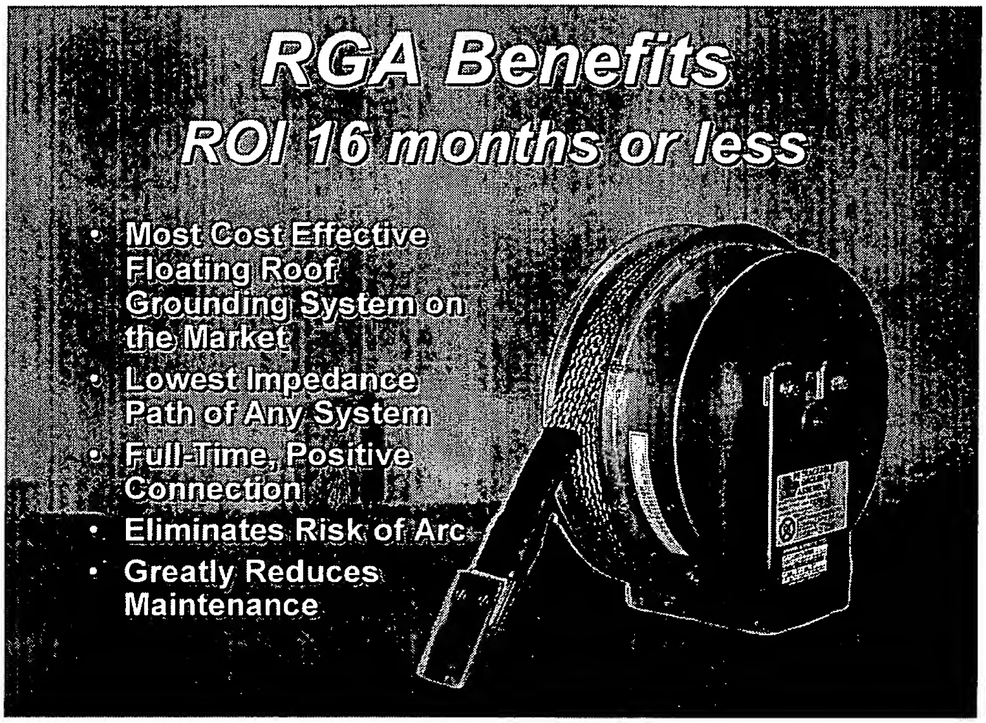


Figure 10.

It is well known and easily proven that any large storage tank possesses the ability to make a solid, low-impedance connection to earth without augmentation from any external grounding electrodes. The sheer weight of the tank, with or without the product, provides the lowest possible impedance connection to earth. The addition of one or numerous grounding electrodes will provide no measurable influence on the final measurement achieved with the tank alone.

Actually, the resistance or impedance to earth is not a problem. The problem of concern is a combination of two factors as listed below:

1. The induced charge on the tank and that induced on the contained product resulting from the influence of the storm cell electrostatic field or that created by the rapid flow of product into the tank must be removed quickly without causing a fire.

2. The poor conductivity between that product and the conductive container is such that it inhibits the discharge process.

NOTE

There is a significant exception when these tanks are constructed over an insulating material such as neoprene rubber. These then result in complete isolation of the tanks and grounding electrodes are required.

Since petroleum products are nonconductors, they tend to hold any induced charge. That charge will, however, slowly migrate toward an attractive conductor of opposite charge. The rate of motion will be inhibited by the natural impedance of the stored product. The shorter the path to the attractive conductor (in this case, the tank wall), the quicker the discharge process. However, the charge near the center of the tank will remain much longer, creating concentration of charge in the middle of the tank. The floating roof of the tank will provide an ideal collector/conductor, if there is a connection to the tank wall and earth. Therefore, the roof offers a critical path for the induced charge for the otherwise isolated center of the tank. Obviously, the larger the tank, the more critical this function becomes. Once the charge is collected, it is conducted to the roof edge. If there is no low impedance between the roof and the wall, there will be an arc and a subsequent fire. If the seals are tight, the fire may not proliferate. However, the risk of a fire is uncomfortably high.

Given this fact, making a good connection between the tank wall and the movable floating roof remains the only grounding problem for these tanks. Some form of positive connection is required that will bond the two together and be independent of the roof position or any seal-related anomalies.

To satisfy this requirement, LEC developed the Retractable Grounding Assembly (RGA). The RGA is a device that provides a direct connection to the tank roof from the tank wall, using a wide and thick-braided wire, wound on a reel and held in tension by spring loading. The path of impedance is held to a practical minimum by the combination of the shortest path, the wide braid and the constant tension. The wide braid is to reduce the "skin effect" at lightning frequencies, and facilitate a tight wind on the reel. The design objective was to achieve the lowest possible impedance between the roof and the wall of the tank. Even the bearings are oilite bronze. See Figure 11.

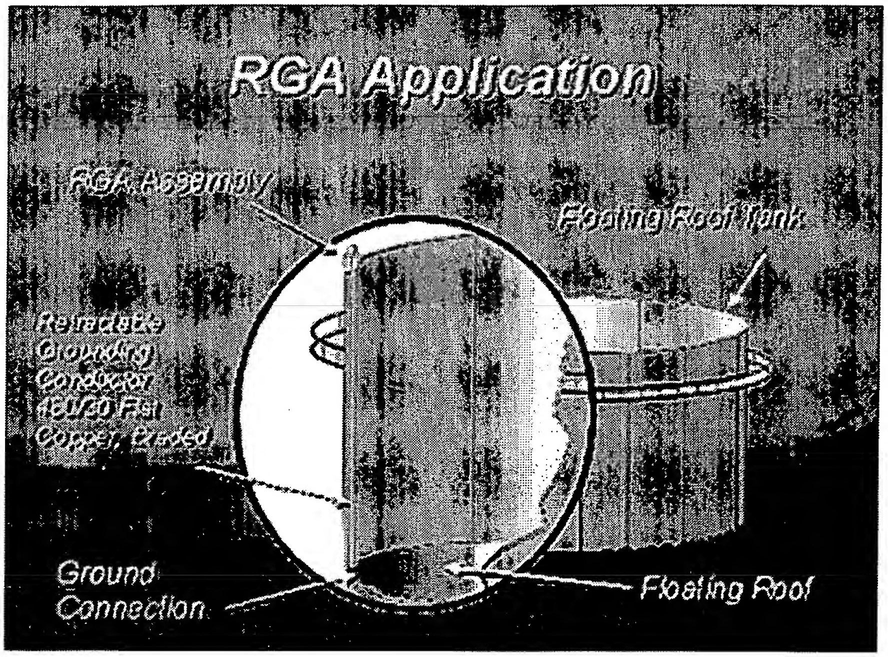


Figure 11.

The reel assembly is constructed from 316 stainless steel, with provisions for mounting on the top edge of the tank . There is one model for edge mounting, and the other for mounting on the top angle. The flat wire end is attached to a roof structure, using several possible options. Since floating roof tanks tend to be of very large diameter, it can accumulate a very large body of charge in the center of the tank. That charge must be carried to the closest location of the tank wall. To assure that path is not too long, at least six or eight RGA's may be required. To limit the roof to wall impedance, the approximate number of these RGA's required is as suggested in the following table:

Tank Diameter		**Number of RGA's Recommended**
(Meters)	**Feet**	
Up to 30	90	2
Up to 50	160	4
Up to 60	200	6
Up to 70	230	7
Up to 80	262	8
Up to 90	295	9
Up to 100	320	10

Please note that these recommendations are based on the worst case impedance situation, where the tank is nearly empty and the roof is resting on or near the tank floor.

Installation Recommendations

The RGA module is designed to be bolted to the top of the tank rim or preferably to the roof itself. The location must be chosen such that they are in perfect alignment, vertically. To install the RGA, it is best to select the anchor point on the roof structure first, and then align the reel assembly so that it is directly above that anchor point. Refer to Figure 12. Where more than one RGA is used, they should be evenly spaced around the tank rim.

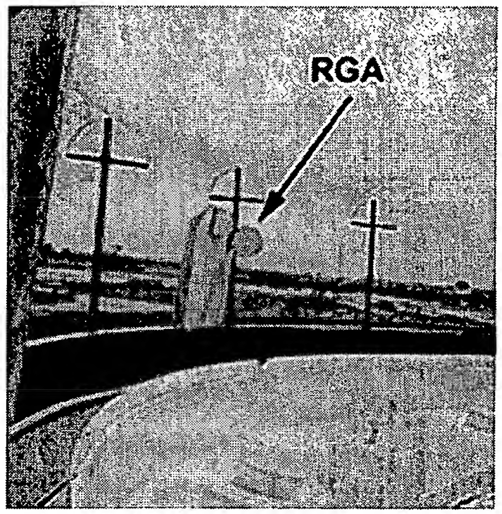


Figure 12

The following models are applicable:

RGA-1	For tanks without reinforcing angle.
RGA-2	For tanks with the top rim angle.

There are only two models of the RGA, because they are universally applicable to all Floating Roof Tanks. The only difference between the two models is the mounting assembly as previously identified.

Figure 13 illustrates a typical RGA wall installation as implemented at several tank farms in Israel.

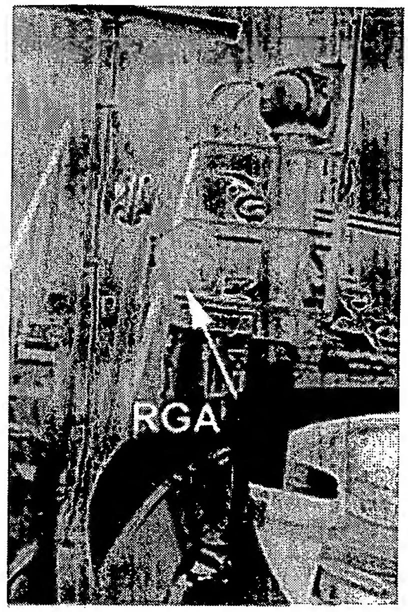


Figure 13

Figure 14 illustrates the roof mounted RGA and the preferred option.

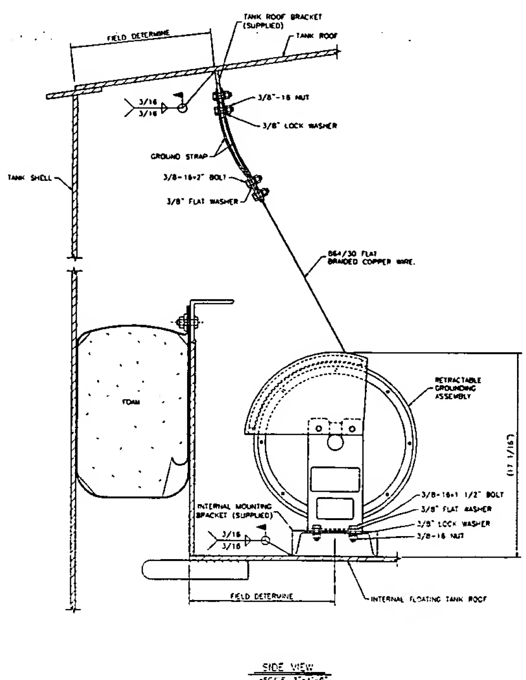


Figure 14

flammable materials through uncontrolled sparking at points relatively distant from the direct stroke.

Such potential differences usually arise when an insulated metallic body is present. The metallic body initially becomes charged through induction at a harmlessly slow rate through its high resistance to ground. When lightning strikes nearby and the ground surface charge is neutralized, a "bound" charge is retained on the body because of the high resistance. This bound charge then causes a voltage release to ground which, if sufficiently large, may cause sparking capable of igniting flammable vapors.

Lightning Characteristics

Lightning strokes vary in their characteristics and generally are divided into two categories, as follows:

1. *High-peak current, but short duration:* This type of stroke has a disruptive effect on electrical insulating materials, such as wood and masonry, but is not likely to start structural fires.
2. *Relatively low-peak current, but long duration:* This type of stroke has little disruptive effect but is quite likely to start fires due to the heating effect of the sustained current flow.

Since either kind of stroke can occur, and either might ignite vapor-air mixtures, it is necessary to provide measures to cover both conditions.

Protection Against Direct-Stroke Lightning

Generally, it is impossible to prevent direct-stroke lightning; therefore, the accepted method of protection is to provide a metallic path to ground of adequate cross-section in order to dissipate the stroke with the minimum of damage. Metallic tanks and structures that are in contact with the ground are sufficiently grounded to provide for safe dissipation of lightning strokes. Artificial grounding by means of driven ground rods is not recommended for such tanks because this method neither decreases nor increases the probability of the tanks being struck, nor does it reduce the possibility of ignition of the tank contents.

Metallic tanks not resting directly on the ground but connected to grounded piping systems are usually sufficiently grounded to provide for safe dissipation of lightning strokes. However, such tanks may require supplemental grounding to prevent foundation damage.

Metallic tanks, vessels, or structures that are insulated from ground can usually be protected by adequate grounding and bonding. Such connections provide a means for dissipating the discharge without causing damage to insulating materials which might be in the direct path of the stroke.

Structures made of insulating materials, such as wood, brick, tile, or concrete, can be protected from direct-stroke lightning by means of properly designed lightning rods, conducting masts, or overhead wires. Such rods, masts, or overhead wires offer lightning protection to objects or structures which fall within a protected zone adjacent to and beneath the highest point of these lightning receivers. The protected zone provided by a mast is considered to be a cone with an altitude equal to the height of the mast and having a base radius equal to the altitude. In less important cases, the base radius may be up to twice the altitude of the mast (see Fig. 16).

Protection of Specific Equipment Against Lightning

Fixed-Roof and Horizontal Tanks: Experience has shown that tanks with fixed metallic roofs or horizontal tanks, maintained in good condition, are well protected from ignition or damage by direct-stroke lightning if all metallic components are in contact.

Metallic tanks with nonconducting roofs cannot be considered to be protected from direct-stroke lightning. These tanks can be protected with a metal covering that is in contact with the shell, lightning rods, conducting masts, or overhead ground wires.

A pressure-vacuum vent or a flame arrester on tank openings will prevent propagation of flame into the tank if there is ignition of the escaping vapor. Pressure-vacuum relief valves, without commercial flame arresters, have been proven by experience to be satisfactory closures for vent openings. *In order to reduce the ignition hazard, some companies forbid the opening of gage hatches during lightning storms.*

Floating-Roof Tanks: Floating-roof tanks without vapor spaces at the seal are considered to be adequately protected from lightning-ignition hazard if the thickness of the metal in the shell and in the roof is adequate to prevent rupture in the event of a direct stroke.

Explosions and fires have occurred in the seal space of floating-roof tanks where hanger mechanisms exist in the vapor space at the seal, even though there was no evidence of a direct stroke. These ignitions are presumed to have been caused by induced (bound) charges in the roof which, when released by a lightning stroke, attempt to return to earth through the seal space and the shell of the tank. This type of ignition can be avoided by multiple bonding (shunts across the fabric

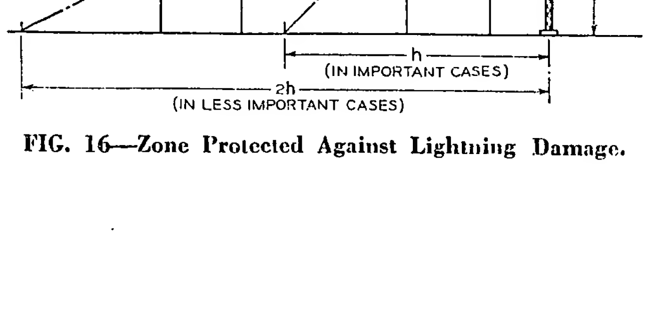


FIG. 16—Zone Protected Against Lightning Damage.

seal) to provide discharge paths that avoid any area where a flammable mixture exists.

A floating roof is occasionally bonded to the tank shell by means of a flexible conductor connected to the ladder or to the tank bottom. Bonding of this type might be of some benefit in draining relatively small indirect lightning discharges. It is ineffective, however, against direct-stroke lightning or severe indirect currents because of the relatively high surge impedance of the bond wire.

Floating-roof tanks that have a metallic fixed roof over the floating roof are considered to be the same as cone-roof tanks insofar as lightning protection is concerned.

Pressure Storage: Metallic tanks, vessels, and process equipment that contain flammable liquids or gas, under pressure, normally do not require lightning protection since such equipment is well shielded from the electric current. In addition, equipment of this type will normally be well grounded and will have adequate thickness to avoid puncture by a direct stroke.

Tankships and Barges: In general, a steel ship or barge can be considered to be protected against damage from direct-stroke lightning if the masts and other projections are adequately grounded to the hull. On ships whose hulls are constructed of wood or other insulating materials, a ground connection from the mast or other projecting metallic structure should be provided by means of a copper plate beneath the water line. Radio antennas should be provided with facilities for grounding during electrical storms.

A ship or barge is subject to indirect induced currents and corona effects which can cause sparking. It is advisable to suspend loading or unloading operations and to close all openings into tanks when severe lightning storms are in the immediate vicinity.

Tank Trucks and Railroad Tank Cars: Experience over a number of years has indicated that tank trucks and tank cars are adequately protected from lightning during normal operation. A complete discussion of all phases of lightning protection can be found in NFPA No. 78.[4]

VI. STRAY CURRENTS

Definition

A stray current is any electrical current, not deliberately applied, which may flow through piping and connected vessels which normally are located in more or less intimate contact with the ground. Such currents may be accidental and of short duration, such as those that arise from the flow of an alternating current during electrical power system fault conditions. On the other hand, they may be persistent, such as those which arise during flow of the direct current of a cathodic protection system. The latter type, although persistent, may remain undetected although electrical testing normally would indicate their presence.

Stray currents are of two types, differentiated according to their source and magnitude:

1. Those resulting from leakage from power lines. Included in this category are stray currents from cathodic protection systems and welding operations. These currents have no definable limits.

2. Those generated by galvanic action associated with soil contact.

Stray currents from source No. 1 are usually of insufficient potential to cause sparks while those from source No. 2 are never of sufficient potential to cause sparks. However, arcs from both sources which result from contact breaking, such as opening a pipe run, may be hot enough to ignite petroleum vapors.

Stray currents pertinent to tank car loading rack operations, as an example, are those currents which result from power leakage from motive-power sources or from the signal systems on main line and industrial railways. Return circuits through the rails and the earth may discharge current into an underground piping system.

Stray Current Hazards

As a result of differences in potential caused by stray currents, arcs have been known to ignite petroleum vapors when pipelines were cut or separated, as at flanges. Buried piping in industrial areas and where cathodic protection is employed should be assumed to carry stray power currents. Even in the absence of power sources, buried piping may carry currents of galvanic origin. Aboveground piping may also carry stray currents due to interconnection with buried piping or leakage from power lines.

Field tests will disclose the presence of currents, as well as their direction and magnitude. Tanks and other metallic vessels, especially those buried in or resting on the ground, must be assumed to be electrically continuous with connecting pipe systems, unless such piping has been artifically interrupted by insulating flanges.

Although the hazard resulting from the opening or cutting of pipelines is emphasized, stray currents may introduce an arcing hazard at facilities wherein metallic systems alternately are connected and disconnected in normal operation, as at tank car loading racks, ship loading wharves, and the like.

The ground return cables of welding machines may introduce a hazard unless attached directly to the work. The practice of attaching ground return cables to pipes or steel structures remote from the welding operations is dangerous because the path followed by the current is unknown and because the current may seek devious paths, resulting in arcs at unexpected locations where flammable vapors may be present.

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To: Peer Review List (attached)

October 2004

Dear Reviewer,

Technical peer review of API/EI research project report findings *'Verification of lightning protection requirements for above ground hydrocarbon storage tanks'*

Request

We are pleased to provide for your information a copy of the findings of the above technical research carried out in 2004. We are seeking your assistance in determining the scope and direction of the Phase 2 research.

Background

The aim of the overall project has been to:

1. Verify whether existing above ground hydrocarbon storage tank lightning protection requirements are adequate;
2. Define practical testing procedures for checking the adequacy of arrangements on tanks in the field;
3. Develop and publish practical guidance on how to maintain these arrangements to ensure continuing adequate protection.

The project was split into two phases, the aim of Phase 1 being to establish the necessary criteria/parameters for the majority of the experimental testing to be carried out in Phase 2.

Current position

Phase 1 was completed in July 2004. Based on the key finding that the shunts provide inadequate contact to prevent arcing and sparking, Phase 2 will not be carried out as originally specified.

Defining the scope of Phase 2

To ensure the greatest value from this work, specifically that the Phase 2 findings will result in practical guidance, <u>we are seeking feedback from industry and key stakeholders on the scope of the work that should be carried out in Phase 2.</u>

The current 'shopping list' of issues under consideration includes:

1) Verification of protection offered by roof earth cable, by comparing hazard levels of different types of sparking (i.e. with and without cable), with both the fast and slow lightning components;
2) Investigate different bonding cable designs for effectiveness, if lightning protection role is proven;
3) Testing of modified shunt designs for above secondary seal shunts;
4) Testing of immersed shunts to minimise the eruption of fluid above the shunt;
5) Testing of steel sheets to determine hot spot ignition risks.

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If you would like to offer any comments on the above, please contact Niall Ramsden who is coordinating the review by no later than **Tuesday 30th November**. If you do intend to submit comments, we would be grateful if you could let Niall know by **1st November**.

You are welcome to forward this request to pertinent colleagues, should they be in a position to contribute their technical expertise to the review.

Documentation for review

The attached 'package' of reports has been formatted for double-sided printing. A **summary** of each of the six reports and their findings is provided at the front of the package to help reviewers determine which reports they may wish to read in greater detail.

Please return your comments and suggestions, preferably in electronic format, to Niall Ramsden, Ramsden@resprotint.co.uk, or by post to: Resource Protection International Ltd, Lloyd Berkeley Place, Pebble Lane, Aylesbury, Bucks, HP20 2JH, England. If you have any queries, please contact Niall on telephone: +44 (0)1296-399311 or fax: +44 (0)1296-395669.

Yours truly,

Alia Alavi
Technical Officer
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